THE MEANING OF "RARE" AND "ENDANGERED" IN THE EVOLUTION OF WESTERN SHRUBS

Howard C. Stutz[1]

ABSTRACT.— In the evolutionary process, species continually come and go. Consequently, all species on earth today were, at one time, "rare and endangered" while in their infancy, and most will become "rare and endangered" once more as they are replaced. Therefore, decisions relative to protecting rare and endangered species are largely meaningless if based on numbers alone. They must include information about their biology and evolutionary history. Lists of endangered forms currently being prepared apparently include only those which are (1) scarce (rare and of restricted distribution), (2) named, and (3) sponsored. Their biological, economic, and academic values may be more important, but apparently are not often considered. As abundantly illustrated in western shrubs, genetically rich genotypes are sometimes maintained by only a few individuals, whereas uniform, and therefore rare, genotypes may in some circumstances, be represented by many individuals in uniform environments. Wise management decisions cannot, therefore, come from numbers alone.

Interpretations of the origin of species indicate that all species now on earth were at one time rare and endangered. Whether they arose slowly by accumulating mutations that permitted divergence from parental forms, explosively as polyploid derivatives, or as recombinants from interspecific hybrids, they all had humble, precarious beginnings. Furthermore, they represent but a tiny fraction of all that might-have-been. Many are undoubtedly inferior to former contemporaneous taxa which, although superior genetically, were lost by fortuitous accidents during their infancy.

As species come and go in response to the challenge of an ever-changing world, some are rare simply because they are new, others are rare because they are being replaced by more adaptive competitors. All species are endangered in the sense that they are successful only as long as the environment in which they are superior endures, or until other modified, improved competitors replace them.

Intelligent intervention in this efficient, sifting, ever-improving drama in the guise of protecting threatened species, requires therefore understanding the evolutionary dynamics which define them. Because artificial protection of any species may concomittantly impose intensified selection against all other associated species, utmost care and caution is essential in management decisions designed to deliberately favor specified taxa. Some species, represented by many individuals but which are genetically uniform, in certain circumstances may be far more in danger of extinction than "rare" species which are genetically diversified.

Protective measures aimed at preserving one particular taxon may be detrimental to the entire ecosystem. However, rare forms which are of high intrinsic value because of their potential for improving an ecosystem, or for providing a fountain of genetic variables from which other new improvements can arise, or for providing economic or aesthetic benefits for mankind may deserve deference and intense protection.

Decisions regarding management of ecosystems designed to preserve "rare" and "endangered" species are therefore always precarious and are essentially indefensible unless founded on intimate knowledge of the genetics and genealogy of affected species.

As rosters of rare and endangered species begin to emerge, it is important that definable criteria be used for deciding whether or not a species is to make the roster. Apparently, to date, only three ingredients are required:

[1]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

(a) Scarcity (rare and of restricted distribution)
(b) A name
(c) A sponsor

Apparently it has had nothing at all to do with value. Also, (b) is not independent of (a) nor is (c) independent of (b). If scarce, a species may not have a name; if unnamed, it will almost never have a sponsor.

Actually, however, because favoring one species may concomitantly disfavor another, decisions cannot really evade value judgements. In my opinion, they *should* not. I would recommend that they deliberately include at least the following:

(a) **Aesthetic values**, including beauty, uniqueness, antiquity, etc.
(b) **Biological values**, particularly in relationship to genetic potential and contributions to the ecosystem.
(c) **Economic values** which would include their contribution to wildlife, to range use, to industry, to recreation, etc.
(d) **Academic values** including contributions to the interpretations of evolutionary history, geological events, climatological changes, and ecological succession.

Illustrations of rare forms which are being replaced and may, therefore, not invite human intervention for their protection, as well as forms which are "brand-new," exciting, promising, arrivals and may, therefore, profitably be enhanced, are abundant in western North America. Recent major geological and climatological changes have provided a multitude of new habitats in which newly formed species have been and still are being favored. Concomitantly, similar other populations have become reduced or extinguished as their required niche disappeared. Examples may be found in nearly all groups of plants and animals; the following are illustrative:

1. THE ROSE FAMILY

In the rose family, *Cercocarpus*, *Purshia*, and *Cowania* have all shown explosive response to recent habitat changes. However, management decisions concerning the accompanying rare and endangered forms of these genera will of necessity vary, simply because each has a distinctive evolutionary meaning.

In *Cercocarpus*, three principal species are known in the Great Basin: *C. montanus*, *C. ledifolius*, and *C. intricatus*. Natural hybrids are common between *C. ledifolius* and each of the other species, but are rare between *C. montanus* and *C. intricatus*, even when they are sympatric (Plummer et al. 1957, Pyrah 1964). *Cercocarpus intricatus* is the most xeric of the three, often growing on steep, exposed limestone cliffs, but it is found only in Utah and the immediate borders of neighboring states. In areas where *C. intricatus* and *C. ledifolius* grow together, there is often such a continuum of intermediates that individual plants are difficult to define. For these reasons, it appears that *C. intricatus* has been recently derived from *C. ledifolius*, having acquired adaptive attributes by rapid genetic assimilation of drought-resistant phenotypes which were, and still are, latent in *C. ledifolius*. Similar evidence, although less straightforward, suggests that *C. montanus* may also have been derived from *C. ledifolius* by selection of types that were more competitive in the more densely vegetated mountain brush zone. The requirement for broader leaves, an apparent prerequisite for competition with *Quercus gambellii*, *Amelanchier alnifolia*, and *Prunus melanocarpa*, was apparently possible only if these broad leaves also became deciduous to escape the long winter drought of frozen soil.

If these interpretations of the recent and continuing evolution of *Cercocarpus* are valid, what might our decisions be, relative to the component rare and endangered forms? *Cercocarpus intricatus*, although recently derived and somewhat rare, is currently not endangered and probably needs little, if any, artificial protection. Its habitat is not often used by man nor by domesticated animals. Very little of the current impact of human civilization appears to be in any way threatening this species.

Hybrids and hybrid derivatives, however, are a different story. Not only are they very rare but they are also very important reservoirs of potential diversity and, in many cases, severely threatened. They are of value as demonstrations of biological evolution, as fountains of genetic combinations from which both *C. montanus* and *C. intricatus* might be enriched and from which even other species might arise, and as beautiful, rare specimens, with simple intrinsic aesthetic value. Although these populations may not represent species, they are important and in many instances deserve deliberate protection. However, because they are unnamed and, perhaps, even unnamable, because the individual plants are the unique rare entities, they may never make the roster.

Purshia and *Cowania*, two other genera of the rose family, are also rapidly evolving and have recently produced several new adaptive products (Stutz and Thomas 1964). While some of the new forms may have come from new mutations, almost all appear to have come as adaptive segregation products from intergeneric hybrids between them.

Purshia tridentata is distributed from southern Utah northward into Canada. *Cowania stansburyana* grows from northern Utah southward into Old Mexico. Consequently, almost the entire state of Utah is an overlap zone in the distribution of these species. In many places in Utah, where these two species come together, hybrids and hybrid derivatives are common. So commonplace is such hybridization there appear to be no populations of *Purshia tridentata* in all of Utah which do not contain introgressants from *Cowania* (Stutz and Thomas 1964). Many, perhaps most, are one of a kind. They apparently continually come and go with few if any ever being superior to their progenitors.

Here then is an example of species in which rare and endangered forms are rampant. But, as interesting as they are or as potentially valuable as they may be, attempts to protect them all would be absurd. Selected forms, or even selected individuals, may be locally desirable, but it would be impossible to preserve every noble segregant. The *Cowania* × *Purshia* F_1 hybrid and the segregating hybrid swarm northeast of Provo, described in detail by Stutz and Thomas (1964), might have been profitably spared but, because they have both already been completely obliterated by a recent housing development, that is now impossible. Protection of similar known F_1 hybrids and hybrid segregants is probably unwarranted. However, specific products that show unique adaptive promise may be profitably protected.

Near Clarkston, Cache County, Utah, a distinctive population derived from *Cowania* × *Purshia* parentage is on the verge of being exterminated by overgrazing. Although considerable segregation is still evident, many of the plants appear to be stabilizing around a unique combination of characteristics which are apparently adaptive in this area. The fruits, leaves, and habit are all intermediate between their putative parents. Because it is unlikely that this small population will survive long under present grazing pressures, adjustments in management of this area would seem highly desirable. However, it is unnamed and unnamable and will probably not make the roster even with me as its sponsor.

Other adaptive products from this parentage include a species of recent origin, *Purshia glandulosa* Curran, and a series of populations of *Purshia tridentata* throughout Idaho, Oregon, and Montana that have been enriched with *Cowania* genes by introgressive hybridization. Because the introgressed populations are being differentially favored by current grazing practices, they apparently require no deliberate protection. Sheep apparently prefer *Purshia tridentata* plants that contain no *Cowania* genes, so introgressed populations are becoming increasingly abundant. These "rare" forms are therefore not at all endangered and may eventually prove to be very abundant and perhaps even detrimental as range forage. In this case, the *rare* does not at all equate with *endangered*. Already it is becoming difficult to find "pure" nonintrogressed populations of *P. tridentata*. In time, they may indeed become the rare and endangered representatives.

Each population of *P. glandulosa* is also somewhat genetically unique. The particular combination of *Cowania* and *Purshia* genes that identifies the adaptive features of *P. glandulosa* is common to all populations, but other characteristics, under less severe selection, apparently segregate somewhat randomly. Consequently, plants in every population are similar with respect to the unique features which characterize them as *P. glandulosa*, but they differ considerably in other segregating attributes. Already *P. glandulosa* as a taxon is sufficiently well established that it is far from being rare or endangered. Although individual variants may be "rare," they appear to be of little consequence in the evolutionary drama that is producing *P. glandulosa* as a newly derived species. Consequently, there appears to be little wisdom in deliberately preserving them even though they meet the rare and endangered criteria.

2. THE OAKS

Much of the variation in *Quercus gambelii* in northern Utah appears to be the result of introgression from *Q. turbinella*. Although in Utah these species are currently sympatric in only a limited area in the southern part of the state, hybrids are common along the Wasatch Front 200 miles to the north (Cottam et al. 1959). According to those authors, the hybrids were apparently left behind during the altithermal postglacial period when, because of milder climates, *Q. turbinella* was able to grow that far north. Although most of the intermediate forms are much alike and may be mostly F_1 hybrids, some segregation is apparent. Both "F_1 hybrids" and segregants are severely restricted to a narrow temperature-inversion belt at about 5,400 feet elevation where temperatures are normally higher than either above or below (Cottam 1959).

These rare hybrid specimens are of high aesthetic value and apparently also of high biological significance. If, as appears likely, much of the expressed variation in *Q. gambelii* is due to introgression from *Q. turbinella* via these hybrids, they have already made great biological contributions and promise to continue to do so as long as we permit them to remain.

However, many of these valuable specimens have already been destroyed and most of those that remain are threatened with extinction. One very unusual hybrid derivative near the mouth of Immigration Canyon, east of Salt Lake City, Utah, has recently been replaced by a house. This particular plant differed from both parents and all other segregants in having oval leaves with serrate margins. The leaves resembled superficially those of chokecherry (*Prunus melanocarpa*). It was a magnificent specimen with a speed of about 40 feet. It should have been preserved. If anything can be done to save the others, they will have longlasting significance biologically, aesthetically, and economically. But these unusual plants (*Q.* × *pauciloba*) may never make the roster.

3. THE SALTBUSHES

Many of the new habitats which have recently become available in North America are still completely unoccupied. Species have not yet evolved that can accommodate the numerous steep mud hills, salt flats, and alkali playas that characterize much of the western deserts. The plants at the borders of these sterile islands, and therefore closest to invading them, are almost all members of the family *Chenopodiacea*: *Salicornia*, *Allenrolfia*, *Sueda*, *Sarcobatus*, *Salsola*, *Hologeton*, *Grayia*, and *Atriplex*. Most of these genera are represented by only a few species and are therefore probably there because of characteristics acquired elsewhere that made them preadapted to these harsh sites. The principal exception is *Atriplex*. This genus is represented by numerous species and varieties, many of which appear to be of very recent origin. In some cases new successful forms appear to be no more than a few years old.

Every known evolutionary force appears to be operative in *Atriplex* at an accelerated rate (Stutz 1978). Species appear to be arising from new mutations, from introgressive hybridization, as new hybrid segregants from interspecific hybrids, as autopolyploids, and as allopolyploids. Rare and endangered forms are therefore abundant. Some are of obvious high value; many others are undoubtedly important.

One of the most successful species of *Atriplex* to invade western North America is *A. canescens* (fourwing saltbush). It has the widest distribution of all native perennial species, growing from central Mexico to Canada and from the Dakotas to the Pacific Coast. With such a wide distribution, it is probably not surprising that it is a highly variable species. Some of the variation is due to phenotypic plasticity, but most of it appears to be genetic.

Four different chrosome levels in *Atriplex canescens* are known: diploids, tetraploids, hexaploids, and twelve-ploids. Rare and endangered forms are found in each.

A. *The diploids* ($2n = 18$)

Individual diploid plants have been found sporadically in several polyploid populations and hence are probably derived by polyhaploidy. They are certainly rare, and certainly endangered. But should they be protected? Probably not. None appears to have any capacity for increasing (partly because, being rare in a polyploid population, they can leave only sterile offspring). With more knowledge, some of them might be recognized as potentially valuable entities and might therefore warrant careful propagation and ultimately increase for some specific use. For the most part, however, we might expect these to be continually produced and continually discarded as novel but nonadaptive variants. Being rare and endangered in this case is probably insufficient license to receive any special protection.

Three distinctive diploid varieties are known, however, which are highly successful in specific habitats and are therefore very valuable. At least one of them is sufficiently rare to be considered endangered. All are probably relics derived from ancestral diploids rather than polyhaploids derived from polyploids.

The most abundant of these diploids, and probably the most ancient, is a form which is common in southern Arizona and also reported from southwestern New Mexico by Max Dunford (oral comm.). It appears to be the most drought resistant of all forms of *A. canescens*, growing sympatrically with creosote bush (*Larrea tridentata*) and mesquite (*Prosopis glandulosa*).

The other two diploids are narrowly endemic. One (*A. garrettii*) grows only in loose sandstone-talus along the Colorado River and at the mouths of its tributaries from 10 miles northeast of Moab, Utah, to Lake Powell. Many populations of this species disappeared with the impounding of water in Lake Powell.

Atriplex garrettii is a very fragile species and would probably be facing extinction were it not for the protection afforded by its inaccessibility in the steep canyons and narrow gorges along the stretch of the river where it grows.

The third diploid form is restricted to the Little Sahara sand dunes in central Utah. It is strikingly different from other *A. canescens* in its gigas habitat. Its growth rate is nearly twice that of the tetraploid forms that grow nearby (Stutz and Melby 1968). This rare form is becoming increasingly threatened. The sand dune retreat has apparently preserved it to date by excluding herbivores that have difficulty in walking on the dunes. Recent development of recreational facilities on the dunes by the BLM as a resort for dune buggy enthusiasts may spell its doom. Many plants are damaged directly by dune buggies; others are destroyed by people. Because this is almost the only woody plant available in this area, it is sometimes used as fuel. It is also highly palatable to livestock and has been harvested to feed horses. Other uses include mattresses for sleeping bags and makeshift windshelters. The handsome fruiting stalks are often gathered for home decoration. During the annual spring dune buggy racing events, thousands of people swarm over these dunes. Even the games they play take a toll.

Although requests have been made to protect this fragile population by restricting vehicle use to a small area, it is apparently going to be difficult to accomplish. This is a rare and endangered form which, although identified by a very vocal sponsor, has still failed to make the roster.

B. *The tetraploids*

Although collectively the tetraploids are abundant and widespread, numerous localized small populations are genetically unique. Many of these are obviously of significant biological value. Several deserve and need protection; others appear capable of holding their own.

Although some of the variation between tetraploid forms may reflect separate polyploid origins, most variations occur as products of interspecific hybridization. The following three examples are among the most common.

(1) *Atriplex canescens* × *confertifolia*.

Hybrids between these very different species have been previously reported by Plummer et al. (1957), Plummer and Drobnick (1966), and Hanson (1969).

The first one I found was in Elko County, Nevada, 10 miles west of Wendover. It was in an area which later became the median between the lanes of a freeway and was therefore destroyed. From seeds harvested from it, however, 17 seedlings were obtained which are now growing in the BYU nursery. All of these plants appear very much alike in habit and leaf characteristics but are distinctively different from either parent and from all other species of *Atriplex*. Differences in fruit characteristic are apparently due to only a few genes which permit clear segregation in this small population. Other characteristics, such as habit, spininess, and leaf characters, do not conspicuously segregate, suggesting a more complex genetic control. Surprisingly, the males show regular meiosis, which implies that most of the differences acquired by these two very distinct species have come from gene mutations unaccompanied by gross chromosomal aberrations.

A large number of hybrids from this parentage have now been collected and progeny from them assembled in a common garden. From these, it appears that at least some of the natural variation present in both parental species has come from introgression from these hybrids. Near Honey Lake, California, a small population of *A. canescens* is obviously heavily introgressed with *A. confertifolia* genes. Near Garrison, Utah, a population of *A. confertifolia* appears to have received genes from *A. canescens.*

Should these hybrids and introgressed populations be included on the rare and endangered roster? Individually, they appear to be fully qualified. They are highly important as sources for new adaptive combinations. Some possibly might represent the beginnings of valuable species if they are spared. Will they need names to make the preferred list?

(2) *Atriplex canescens* × *A. cuneata.*

Although *A. canescens* is a large woody plant and *A. cuneata* is a low-statured herbaceous perennial, hybrids between them are common. They have been reported by Plummer et al. (1957), Plummer and Drobnick (1966), and Hanson (1969). Stavast (unpubl. no.) reported an extensive population of hybrid segregants west of Hanksville, Sevier County, Utah.

From natural hybrids, segregating seedlings have been grown to maturity in the BYU nursery. While most of them are more like *A. canescens* than like *A. cuneata* in habit and fruit characteristics, *cuneata* influence is unmistakable.

From observations of these garden-grown segregants, it has since been possible to identify several distinct introgressed populations in nature. One particularly striking form is becoming established near Ferron, Emery County, Utah, as a low-statured form, with small fruits and a capacity for growing with and favorably competing with, *Ceratoides lanata* and *Xanthocephalum sarothrae*, which neither parent can do. It now occupies only about 40 acres so is still rare and, of course, endangered. It may be the beginning of a very valuable addition to our rangelands if we can preserve it.

Other novel adaptive combinations from this same parentage are likely also forthcoming if the source is protected.

(3) *Atriplex canescens* × *A. gardneri*

Many years ago A. Nelson reported hybrids between *A. canescens* and *A. gardneri* and named them *A. aptera* (Nelson 1904). Such hybrids are still common west of Laramie, Wyoming, and elsewhere where these two species meet. They appear to have given rise to a series of very successful derivatives which now occupy the banks of most of the tributaries of the Missouri River in Montana, southern Alberta, southern Saskatchewan, North and South Dakota, and northwestern Nebraska. It was a specimen of this form which was collected by Lewis and Clarke in 1804 north of Chamberlain, South Dakota, and to which the name *A. canescens* was assigned. In most places it is low growing and shows vigorous root-sprouting, but some are quite woody. Some have broad wings on the fruiting bracts; some show only small traces of wings. Apparently segregation is still going on as unique combinations find habitats in which they are competitive.

Collectively these hybrid products are not at all rare or endangered, but local unique populations certainly are. Should they receive protection?

Several other interspecific hybrids involving tetraploid *A. canescens* from which segregating progeny are sometimes abundant and stabilized, sometimes rare and variable, have been found in western North America. Some have already yielded new adaptive incipient species; others may yet do so from the rich common gene pool. Some of them will obviously require protection if they are to become established. Others already appear to be sufficiently established to be able to continue even with human assaults.

C. *The hexaploids*

Within many tetraploid populations of *A. canescens*, occasional hexaploid plants have been found. They are apparently continuously and sporadically produced from unreduced gametes. For the most part, they have not become established as separate adaptive derivatives. This is probably due primarily to the high improbability of two such hexaploid plants being produced simultaneously in sufficiently close proximity to each other to interbreed, and also, even if they did, it would be unusual for their offspring to be an improvement over the parental forms.

Even so, a few exceptional, small, localized hexaploid populations have been found in isolated pockets. In the White Sands National Monument, New Mexico, some very promising hexaploids have become established in localized colonies fairly close to the more abundant tetraploid form. In the BYU nursery, they show a shorter, more compact habit than the tetraploids and may have attributes which would be superior in particular range conditions. Because they are still few in number and sporadic in distribution, they could profitably use protection, but under current policy they appear to have little chance of receiving it though their existence under circumstances that severely hinder their establishment suggests they may have great potential for success once they get started.

The ephemeral hexaploids that appear as single plants in tetraploid populations, although rare and of course endangered, probably do not merit legislated protection, simply because they cannot demonstrate particular values until removed from their tetraploid neighbors and manipulated by plant breeders. Their potential may be high, but protecting them in their ephemeral infancy is probably not warranted, although they apparently meet all current prerequisites except for having designated names.

In contrast to rare, ephemeral, and localized small pockets of autohexapaloids, there are several allohexaploids that appear to hold great promise as new additions to the desert ranges. One of these is already abundant in the north-south-oriented valleys of Nevada. It appears to have been derived from the parentage 4N *A. canescens* × 2N *A. falcata*. Apparently doubling of the chromosomes in the triploid F_1 hybrid gave rise to a remarkably well-adapted new taxon. It is a short-statured form that often flowers during its first year of growth. Because there are marked differences between different populations, they have apparently arisen repeatedly at different places. Although, collectively, this hexaploid is well established, successful, and apparently capable of withstanding intensified grazing pressures, some of the individual component populations are genetically distinct and apparently sufficiently rare to be endangered. Should we attempt to protect these new arrivals during their fragile infancy, or shall we settle for the already acquired forms which are performing at least satisfactorily?

Another hexaploid fourwing derivative that appears to offer unique and exciting promise as a new adaptive taxon, has apparently come from the parentage 4N *A. canescens* × 6N *A. tridentata*. This interesting form occupies only about 80 acres east of Grantsville, Tooele County, Utah. It is upright and woody like typical nearby tetraploid *A. canescens* plants, but it has soft-textured furfuraceous leaves and late-maturing flowers and fruits like *A. tridentata*. It also grows on heavy clay soils as does *A. tridentata*.

This small population appears to be remarkably adapted to this valley and is apparently spreading. Currently almost entirely within a military reserve, it is already receiving needed protection during its infancy. However, if that protection were removed, the entire population could very quickly be lost. Indeed, were it not for the presence of the reserve, it may have never survived beyond its birth.

A hexaploid *A. tridentata*-like derivative from this same parentage has apparently come into existence only during the past decade. It is still confined to the roadsides along a 30-mile stretch of freeway between Salt

Lake City and Wendover. Because the freeway itself is only about a decade old, the new adaptive derivative must also be no older than that. In the center of the population, *A. tridentata* and *A. canescens* are sympatric. Hybrids and hybrid products, as well as the new stabilized segregant, are all present. In the summer of 1977, an actual count was made of the plants of this new form. On the roadsides of the lanes leading westward into Wendover, 17,600 plants were counted. Assuming approximately the same number on the roadside of the lanes leading eastward toward Salt Lake City, the total population consists of only about 35,000 plants. It is still rare, but as long as the highway is there there is little threat to its continuation. This portion of the freeway is mostly across empty salt flats, so grazing and other biological pressures are essentially absent. Conceivably, these robust, unique plants may be preadapted for occupying areas other than the side of the freeway, in which case they may one day find an escape from this restricted island. In any case, legislated protection is probably meaningless, despite their rarity and high intrinsic aesthetic and scientific value.

D. *The twelve-ploids*

Atriplex canescens var. *laciniata* Parish is distinguished by fruit bracts that are thin and lacy. It is common sporadically in much of the Mojave Desert, with extensive populations near Barstow, California, and around the Salton Sea. It is apparently an allopolyploid derived from the hybrid *A. canescens* × *A. polycapra*.

Although this extraordinary species is now well established and apparently in no need of protection, it hybridizes freely with both *A. canescens* and *A. polycarpa*, yielding numerous novel progeny, each one of which is rare. Although most are aneuploids, some of them may be preadapted for habitats yet uninhabited.

Parallel examples can be drawn from other groups of saltbushes and probably from many other desert plants. Rare taxa and endangered taxa are commonplace in these rapidly changing environments. The problem then is not one of finding them or defining them, but, rather, understanding them. Not until we know their biology and their genealogy can sound decisions be made concerning their management. Large, genetically uniform populations may be, biologically, much more endangered than smaller but heterogenous populations. Genetically they are certainly more rare.

In terms of management then, it is far more important to identify rare and endangered genotypes than rare species. In some instances species having abundant genetic variation and few individuals may be much less endangered than species having limited genetic variation, albeit many individuals.

Conclusion

It appears clear, therefore, that the meaning of "rare and endangered" must extend beyond mere head counting. Abundant individuals may not always mean abundant and therefore secure genotypes, and vice versa: species represented by only a few individuals may be so rich genetically that their continuance, under almost any normal environmental assault, is essentially certain. Equally important, in view of the cost to ecosystems, to human society, and to other contemporary organisms, some rare forms may not warrant preservation at all. A sterile, weak polyhaploid derivative with essentially no potential for amounting to anything of value cannot justify protective measures merely because it is rare and endangered. A dinosaur pet, as fun as it might be to have, would be prohibitively costly just to feed—let alone to house and to exercise. On the other hand, new exciting infant forms with rich potential for high aesthetic, biological, economic, or academic values should be encouraged and their establishment and growth accelerated. To tell which of the rare forms are coming into existence and which are going out requires intimate knowledge of their biology and genealogy. Simply enumerating named taxa which are rare is not enough. If we are going to meddle in the evolutionary process, let us do it intelligently. Otherwise it would be better that we do not meddle at all.

Questions for Dr. Stutz

Q. Howard, how are you going to choose which ones you are going to save?

A. I would expect that value judgements will be used just like we use them in creating priorities in every decision we make in life. We categorize them. So I think that if I were given an array of choices I could make that decision on the basis of relative value. But it's not going to be a simple recipe. It's going to be based on intimate knowledge of the species being considered.

Q. But you mean they are going to be entirely based on man?

A. In the absence of that, then we would have to do as has been suggested by several, including Dr. Stebbins and Dr. White. We simply maintain the ecosystems, refrain from imposing our personal preferences, and let natural selection make the choice. Then we're removed from that dilemma. I think, in many cases, ultimately that's what has to happen. It's obvious we cannot put everything into a wilderness protected area, but we need to have preserves. We need to provide opportunities where the evolutionary process can proceed without our intervention. On the other hand, there are situations where we must evaluate. We will have to decide whether to plow that field or to put in that hydroelectric plant. When it is necessary to impose human decisions, then we must also impose human value judgements. At that point we need all of the biological information we can possibly get to make those decisions. They must not come simply from a knowledge of numbers of individuals alone.

Dr. Stebbins: First I think this is a fascinating topic, but I'd like to bring this whole question of preserving or not preserving into the context of what you said about intelligent meddling with evolution. I think in this case, if we're going to understand evolution, we want to make it go. After all, the engineer doesn't just look at what electric motors did in the past, he makes new ones. Now in the case of the examples you have in both your *Purshia-Cowania* and your *Atriplex*, it impresses me that these obviously recent populations have not yet fitted in to any particular ecological niche. The way to save them, in my opinion, is to gather large numbers of seeds and meddle just a little bit by finding out just what kind of ecological niches they prefer. Those that aren't likely to be disturbed will be happy homes for these things and will then lead on to something new and still different. I'm particularly interested in this stabilized *Purshia* colony in that connection. You should go up there and ask permission from that rancher to get all the seeds you can and grow them somewhere along the margin there and just see if you can't find a place where it will be more than just a puny little population. In the case of your Wendover freeway, heavens knows there are miles and miles and miles of freeway that have nothing but *Salsola kali*, for instance. Wouldn't it be nicer to have this thing rather than Russian thistle or halogeton?

A. The answer is in the affirmative. I'm glad you brought that into perspective, Dr. Stebbins, because we have another great opportunity before us today which needs to be exploited. That is the sudden availability of new environments provided by mining operations in which we can do this very thing. Dr. Frischknecht of the Forest Service Shrub Laboratory is working on preparing plants which will be able to tolerate oil-shale refuse dumps. Also with strip mining, there are brand new islands made available and new areas in which we can do just exactly as Dr. Stebbins suggested. We can introduce gene pools into these new arenas and watch them evolve. We can monitor the evolutionary changes and we can get a record of evolutionary dynamics like we've never been able to before. We need to cooperate with industry and use their by-products to help us learn more about succession and evolution.

Dr. Stebbins: Let me just mention this. I think it's novel, but I don't know how many of you know about it. If you have read the books of the marvelous scientific philosopher, Rene Dubois, he has made the comment that we Americans are too wilderness oriented because we, or our ancestors, were brought up in or near pioneer habitats and wilderness, whereas Dr. Dubois was brought up in the vicinity of Paris. He knows country as cultivated land, as well-manicured forests, and sees the beauty in that. Isn't there some justification in our thinking in terms of producing a pleasing landscape of human manufacture from many of the areas which are just junk now and, at the same time, of course, preserving the wilderness?

Dr. Deacon: A couple of comments, one fairly specific. It is possible to include unnamed entities. I think that's one of the criteria that need not be met. The listing process that I've been involved with has something like over 10 percent unnamed taxa.

Dr. Stutz: How are they listed? With a number?

Dr. Deacon: They're simply referred to as a subspecies with a common name that's distinctive or unique to that group. In other words, what is necessary is to realize that it is unnecessary to actually go through the process of naming.

Dr. Stutz: This entity, for example of *Purshia-Cowania*. I suppose we'll need a handle before it can even get on the roster. That was my only point.

Dr. Deacon: Not the formal scientific name. But more serious than that, in my view, was the illustration of the coyote/rabbit: if you save one, you're likely to save the other. It's the same sort of illustration that Congressman McKay used with respect to the Colorado squawfish eating the humpback chub. The point is, if you save an evolving ecosystem you save all parts of it. Just because you kill an individual doesn't mean you kill the species so that the evolution of predator/prey is what must be preserved. I would hope you might reconsider using that illustration.

Dr. Stutz: I already have.

Dr. Deacon: The other point I would like to make in that respect is that certainly the consideration of value, which is the main point of your talk, is really the most difficult thing we have to deal with here, and when you come to the process of involving economic value, it looks like one of the most fruitful possibilities for consideration. The discussion presented so nicely to us yesterday by Dr. Spencer is perhaps one of the most optimistic I've heard presented here from the standpoint of the pressure already in existence. I think he represented to us the changing social values that are in fact forcing us into the changes necessary for us to establish "a worldwide sensible economic system."

Mr. Clement: This is a fascinating evolution in refining our expression of what we're concerned about, and let me add one more fact: distinguishing between economic and fiscal valuation. Most of what we call economic is fiscal, private concern about economic return. and when you come to valuing in a broad sense, all values are economic, because we're dealing with scarce resources, whether they're material, aesthetic, or spiritual.

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